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# SUNSET AS AN ORIENTATION CUE IN WHITE-THROATED SPARROWS[1]

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ABSTRACT. The importance of sunset as a fall orientation cue in the white-throated sparrow (*Zonotrichia albicollis*) was examined under clear skies, cloudy skies, and after sparrows were denied sunset exposure. Sparrows tested during sunset under clear skies exhibited a significant southerly orientation. Those tested under cloudy skies exhibited a more dispersed orientation which was not significant. Sparrows denied sunset exposure but allowed to view stellar cues, exhibited a marked decrease in activity and no directional preference. Results suggest sunset is a primary visual cue functioning in selection of direction prior to nocturnal fall migration.

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## INTRODUCTION

Oriented migrants require a periodic, if not a continuous input of directional information. Environmental sources of this information are called "cues" and enable a migrant to select or maintain a bearing on its migratory journey (Moore 1980). Sunset is one possible cue because it coincides with the time most nocturnal migrants initiate their migratory journey (Emlen and Demong 1978).

Moore (1978) presented the first experimental evidence that the time of sunset plays a crucial role in the compass orientation of savannah sparrows (*Passerculus sandwichensis*). He further demonstrated (Moore 1980) that sunset was a sufficient source of directional information for seasonally appropriate orientation, and sparrows change their orientation direction when the perceived sunset is altered by mirrors (Moore 1982).

Emlen and Demong (1978) showed that white-throated sparrows (*Zonotrichia albicollis*) when released in spring assumed

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the appropriate migratory direction at twilight. Bingman and Able (1979) tested sunset as an orientation cue in white-throated sparrows in the fall, but only under clear skies. The purpose of this study was to examine sunset as an orientation cue in the fall migration of white-throated sparrows and to determine whether white-throats could rely on other sources of directional information when a view of the sunset is either denied or obscured.

## METHODS AND MATERIALS

Tests were run at the Miami University Ecology Research Center near Oxford, Ohio, between 19 October and 15 November 1981. White-throats were mist netted in Oxford, color banded and aged. They were kept outdoors in individual holding cages between tests.

Orientation tests were run in funnel cages (Emlen and Emlen 1966) which provided a record of the sparrows' directional preference and activity. Tests were run outdoors under: clear skies; overcast skies to determine the orienting ability of sparrows when sunset is obscured, and clear night skies without exposure to sunset to determine if sunset was indeed necessary for appropriate migratory orientation. Sparrows were placed in the funnel cages at sunset for the first 2 conditions. For the third condition, sparrows were kept indoors all day and placed in the funnel cages after the end of twilight. Sparrows remained in the funnel cages for 2 hr after the end of sunset for all 3 conditions. Ten sparrows were used for the study.

The mean direction of activity ($\bar{a}$) was determined by vector analysis (Emlen and Emlen 1966), and the pooled test means for the first 2 conditions were statistically tested using Rayleigh's test of concentration (Zar 1974).

## RESULTS AND DISCUSSION

There was a definite southerly trend in the orientation of white-throated sparrows tested under clear skies (fig. 1A). This trend is also indicated (table 1) by the mean angles ($\bar{a}$) and measures of concentration (r). A higher r value indicates the activity was more concentrated in the direction of the mean angle. Under clear skies, the sparrows exhibited a significant southerly orientation ($P < 0.05$), ($\bar{a} = 174°$, $r = .8981$). Bingman and Able (1979) tested white-throated sparrows only under clear skies in the fall and showed that sparrows also exhibited a significant southerly orientation.

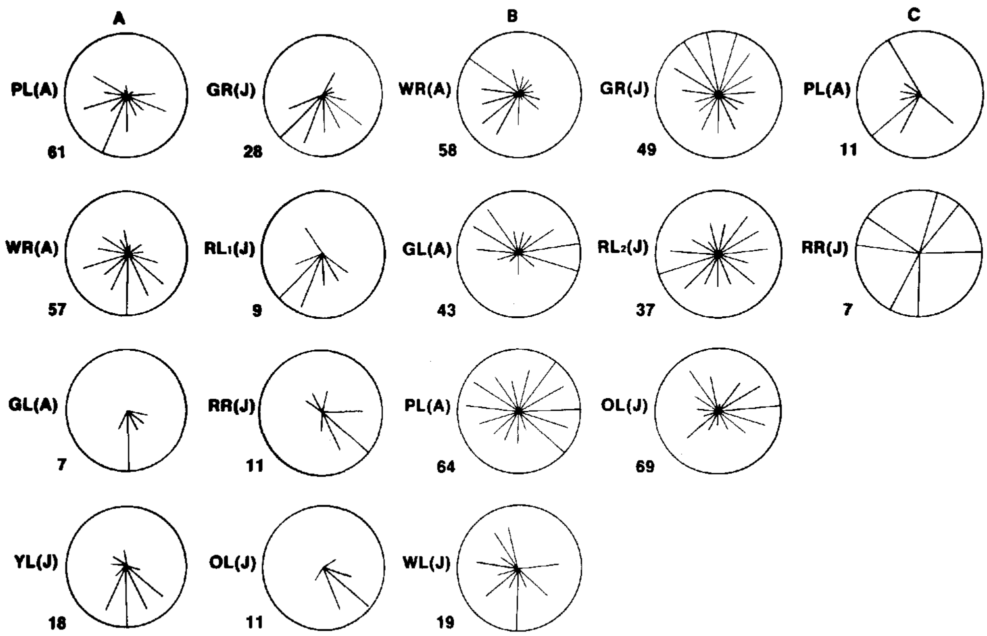


FIGURE 1. Individual fall orientation records of white-throated sparrows tested under: A, clear skies; B, overcast skies and C, no sunset exposure. Numbers at the lower left are the total number of units of activity (N).

TABLE 1
*Orientation behavior of white-throated sparrows in the fall of 1981.*

| Test | Bird | Age | +N | $\bar{a}$ | r |
|---|---|---|---|---|---|
| Clear Skies | PL | A | 61* | 200° | 0.3464 |
| | GL | A | 7 | 164° | 0.8639 |
| | WR | A | 57* | 197° | 0.3407 |
| | RR | J | 11 | 131° | 0.4426 |
| | $RL_1$ | J | 9 | 208° | 0.6652 |
| | YL | J | 18 | 179° | 0.6050 |
| | OL | J | 11 | 135° | 0.8359 |
| | GR | J | 28 | 177° | 0.4850 |
| Overcast Skies | PL | A | 64 | 29° | 0.1656 |
| | GL | A | 43* | 65° | 0.2206 |
| | WR | A | 58* | 244° | 0.2575 |
| | $RL_2$ | J | 37 | 174° | 0.0339 |
| | OL | J | 69* | 23° | 0.1677 |
| | GR | J | 49 | 351° | 0.1819 |
| | WL | J | 19 | 226° | 0.2504 |
| Denied Sunset | PL | A | 11* | 249° | 0.3603 |
| | RR | J | 7 | 309° | 0.1075 |
| | $RL_2$ | J | 6** | — | — |

+N — Total number of units of activity for a given test.
$\bar{a}$ — Mean direction of activity.
r — Measure of concentration, varies inversely with the amount of dispersion.
* — Bird was tested twice under the same condition.
** — Not enough activity to determine $\bar{a}$ and r.

Under overcast skies the sparrows did not show a significant orientation ($P > 0.05$), ($\bar{a} = 6°$, $r = .1548$). Individual r values were also lower than those of sparrows tested under clear skies (table 1), which suggests that sparrows exhibited a random orientation behavior (fig. 1B) when sunset was obscured by clouds. Sparrows released by Emlen and Demong (1978) under overcast skies in the spring were able to determine a northerly heading but with much less accuracy than under clear skies. The difference in our results may be due to the methods used. Emlen and Demong (1978) released their sparrows and determined their vanishing directions while our sparrows were tested in Emlen funnel cages.

The sample size for sparrows denied sunset exposure is too small to provide any significant conclusions about their orientation behavior. However, the trend seems to suggest random orientation and a decrease in activity (fig. 1C, table 1).

Directional information could also be obtained from the geomagnetic field on overcast days and nights when the sun, moon, and stars are obscured (Moore 1980). Bingman (1981) showed that savannah sparrows possess a magnetic compass. The white-throated sparrows we tested under overcast skies did not exhibit a significant orientation. While this suggests that they did not rely on a magnetic compass, this does not rule out the possibility that white-throated sparrows possess a magnetic compass.

Sunset is a dominant visual cue occurring at precisely the time prior to most nocturnal migratory departures (Emlen 1975) and seems to be necessary in the fall migration of white-throated sparrows. Only when sparrows were tested under clear skies did they exhibit a significant southerly orientation. Nocturnal migrants cannot refer to the sun directly during migration, but solar cues could be useful in determining take-off directions or correcting in-flight displacements (Able and Dillon 1977).

The general consensus today is the existence of a multi-cue system (Moore 1980). This may take two forms: a redundant system where directional information is dependent on availability and pooling of a variety of cues; or a hierarchal system where a migrant relies on a primary orientation cue from which other systems are dependent (Moore 1980).

White-throated sparrows seem to possess a hierarchal multi-cue system. Once the appropriate migratory direction is selected from the setting sun, this direction could then be maintained by secondary cues, possibly the stars, magnetic fields, or polarized light (Able 1982).

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